

# Thirty-day mortality after elective and emergency total colectomy in Danish patients with inflammatory bowel disease: a population-based nationwide cohort study

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## ABSTRACT

**Objectives:** The purpose of this investigation was to assess 30-day mortality among Danish inflammatory bowel diseases (IBD) patients and to examine the prognostic impact of hospital total colectomy volume, age, gender and comorbidity.

**Design:** Cohort study.

**Setting:** The authors compared 30-day survival over the period 1996–2010 among 2889 IBD patients with total colectomy identified in the Danish National Registry of Patients. This registry covers all hospitals in Denmark. Postoperative survival patterns for patients with ulcerative colitis and Crohn's disease were compared, using proportional hazard regression. The regression model accounted for the timing of surgery, hospital total colectomy volume, age, gender and comorbidity.

**Participants:** Patients were enrolled in the study if they had a hospital registry diagnosis of IBD, with accompanying procedure codes for total colectomy (see codes in online appendix table 1). Hospitalisations were described as elective or emergency, and patients were categorised as having Crohn's disease, ulcerative colitis or as a mixed group.

**Outcome measures:** Primary outcome measure was 30-day mortality.

**Results:** Among 2889 IBD patients with total colectomy, 1439 (50%) underwent surgery during an emergency hospitalisation. Thirty-day mortality was 5.3% (76/1439) among emergency cases compared with 1% (14/1450) among elective cases. The highest mortality (8.1%; 11 of 136) was observed among Crohn's patients undergoing emergency surgery. The mortality of patients with ulcerative colitis undergoing emergency surgery was 5.2% (55/1056). After elective surgery, the 30-day mortality was 0.9% (8/938) among patients with ulcerative colitis and 1.5% (3/201) among Crohn's disease patients. Low hospital total colectomy volume, comorbidity and high age were associated with increased 30-day mortality in ulcerative colitis patients undergoing emergency surgery.

**Conclusion:** Emergency total colectomy among patients with ulcerative colitis and particularly

## ARTICLE SUMMARY

### Article focus

- Elective and emergency total colectomy is commonly performed in inflammatory bowel disease.
- Emergency operations are associated with higher mortality than elective procedures.

### Key messages

- IBD patients undergoing emergency total colectomy have a 30-day mortality of 5.3% as opposed to 1% after elective total colectomy.
- Low hospital volume, high age and comorbidity are associated with increased mortality in patients with ulcerative colitis undergoing emergency surgery.
- It is suggested to centralise treatment, and to aim for elective procedures in high-risk patients.

### Strengths and limitations of this study

- The study covers complete national data on total colectomies performed for inflammatory disease.
- The unique ID number of all patients makes recording of all events highly reliable.
- The main limitation is lack of access to specific clinical parameters.

Crohn's disease is associated with substantial 30-day mortality.

## INTRODUCTION

Inflammatory bowel diseases (IBD) cause serious morbidity and disability in people of all ages. Medical treatment remains the cornerstone for managing these diseases. Over the past two decades, use of immunosuppressants such as azathioprine<sup>1 2</sup> has increased significantly as a treatment modality. More recently, potent biological treatments have proved effective in treating

both ulcerative colitis and Crohn's disease.<sup>3–7</sup> Historical data have shown that up to 83% of patients with Crohn's disease underwent at least one bowel resection during a 10-year period<sup>8</sup> and up to 25% of patients with ulcerative colitis needed surgical treatment.<sup>9</sup> While some recent studies show that modern medical treatment may decrease the need for surgery in IBD patients,<sup>10–12</sup> others suggest that this is not the case.<sup>2 13</sup>

In patients with severe ulcerative colitis, colectomy rates have remained stable over the past decades,<sup>14</sup> although the introduction of biological rescue therapy is likely to decrease use of this surgical intervention in coming years.<sup>15 16</sup> Mortality rates of up to 30% have been reported historically in patients undergoing emergency total colectomy for ulcerative colitis.<sup>17 18</sup> Delay in patient referral for surgery has been proposed as the reason for high postoperative mortality.<sup>19</sup> Although recent data from a highly specialised centre showed in-hospital mortality of <1% after emergency colectomy,<sup>20</sup> population-based studies from England<sup>21</sup> and the USA<sup>22</sup> have reported postoperative mortality as high as 5.4%–5.7% after emergency colectomy. This contrasts with rates as low as 0.7%–0.8% after elective colectomy. Advanced age, comorbidity, delay of more than 6 days between hospital admission and colectomy and low hospital volume have been associated with increased postoperative mortality after colectomy in IBD patients.<sup>22 23</sup>

In many countries, including Denmark, increasing specialisation has occurred, with more rare and complicated conditions treated at specialised centres. Still, severe IBD continues to be treated at general district hospitals, where the number of patients is low and outcome appears to be poor.<sup>24</sup>

The present study aimed to investigate 30-day mortality after elective and emergency total colectomy in Danish IBD patients, with special emphasis on the prognostic impact of hospital total colectomy volume, age, sex and comorbidity.

## MATERIALS AND METHODS

We conducted this follow-up study in the setting of the entire Danish population of 5.4 million people during the period 1 January 1996 to 31 December 2010. The Danish National Health Service provides tax-funded medical care for all Danish residents.

### Data sources

The Danish National Registry of Patients (DNRP) contains data on all non-psychiatric hospitalisations in Denmark since 1977 and on hospital outpatient clinic contacts since 1995.<sup>25</sup> The DNRP records civil registration number, hospital code, department code, date and type of admission (emergency/elective), dates and codes of procedures, admission and discharge dates, selected medical therapies and up to 20 discharge diagnoses, coded by physicians according to the International Classification of Diseases (ICD), eighth revision until the end of 1993 and 10th revision thereafter. It is mandatory that all surgical procedures are coded according to the

Nordic Medico-Statistical Committee (NOMESCO) classification.<sup>26</sup>

We linked individual-level data from the DNRP using the civil registration number, a unique 10-digit identifier assigned at birth to all Danish residents by the Civil Registration System.<sup>27</sup> The Civil Registration System also tracks vital status and the residence of all Danish citizens and is updated daily.

### Patients with IBD and total colectomy

Patients were enrolled in the study if they had a hospital registry diagnosis of IBD, with accompanying procedure codes for total colectomy (see codes in online appendix table 1). Hospitalisations were described as elective or emergency, and patients were categorised as having Crohn's disease, ulcerative colitis or as a mixed group if their records contained ICD codes for both Crohn's disease and ulcerative colitis. We also obtained information on reoperation occurring within 30 days of the primary surgery, tumour necrosis factor  $\alpha$  inhibitor and cyclosporine treatment in the year prior to surgery and *Clostridium difficile* infections (see codes in online appendix table 1). We categorised IBD patients according to age at date of total colectomy (0–39, 40–59 and 60+ years), year of colectomy (1996–2000, 2001–2005 and 2006–2010) and hospital total colectomy volume defined as annual number of total colectomies performed on IBD patients by the surgical department and categorised according to Kaplan *et al*.<sup>22</sup> (low: <3, medium: 3–12 and high: 12+).

We also extracted information from the DNRP on comorbidity, that is, diseases coexisting with IBD. We summarised comorbidity status using the Charlson Comorbidity Index (CCI).<sup>28</sup> The CCI's scoring system assigns between one and six points to a range of diseases. Each patient's sum of points represent a measure of his or her comorbidity burden. We placed our study patients into three groups according to their sum of points: 0 points ('no comorbidity'), 1–2 points ('low comorbidity') and 3 or more points ('high comorbidity').<sup>28</sup> We defined comorbid diseases according to the ICD-10 codes provided by Quan *et al*.<sup>29</sup>, matching ICD-8 codes to ICD-10 codes as closely as possible (see codes in online appendix table 2).

### Mortality data

We followed IBD patients who were acutely or electively hospitalised for a procedure of total colectomy in the period 1996–2010, from the date of colectomy until death, 30 days postsurgery or 31 December 2010, whichever came first.

### Statistical analysis

Our main outcome of interest was 30-day mortality, estimated as the number of deaths after total elective or emergency colectomy divided by the total number of IBD patients undergoing elective/emergency colectomy. We stratified our study sample by IBD type and by the following covariates: gender, age at colectomy, year of

colectomy, hospital total colectomy volume,<sup>22</sup> duration of hospitalisation prior to surgery (<8 days, ≥8 days), presence or absence of tumour necrosis factor- $\alpha$  inhibitor or cyclosporine therapy in the year before the total colectomy, reoperation, CCI score and colectomy subtype. We calculated differences in mortality and corresponding 95% CIs between patients undergoing emergency versus elective surgery overall. We also calculated mortality rates for ulcerative colitis patients by age and hospital total colectomy volume. In addition, we used Cox proportional-hazards regression to estimate mortality rate ratios (MRR) for each covariate, using the reference values shown in table 4. MRRs were adjusted for age (0–39, ≥40 years), gender and CCI score (0 and ≥1 points) to evaluate the independent prognostic effect of the covariates included in the model. (We lacked statistical power to mutually adjust for all covariates.) In a subsequent analysis, we estimated the proportion of patients who underwent reoperation, as a secondary outcome.

## RESULTS

### Descriptive data

In total, 2889 IBD patients with total colectomy were identified from the DNRP for the period 1 January 1996–31 December 2010. Of these, 1439 (49.8%) underwent surgery during an emergency hospitalisation (49% women). Characteristics of IBD patients by type of surgery (elective and emergency) are shown in tables 1 and 2. The majority of patients had a total colectomy due to ulcerative colitis (64.7% for elective cases; 73.4% for emergency cases). Of the 1450 elective cases (51.9% women), 718 (49.5%) were younger than 40 years, 438 (30.2%) were between ages 40 and 59 and the remaining 294 (20.3%) were ≥60 years old (table 1). Of the 1439 emergency cases, 693 (48.2%) were younger than 40 years, 390 (27.1%) were between ages 40 and 59 and the remaining 356 (24.7%) were ≥60 years old (table 2). The majority of elective (69.9%) and emergency (65.1%) surgeries took place in high-volume hospitals with >12 total colectomies/year (tables 1 and 2). None

**Table 1** Characteristics of patients with an IBD diagnosis undergoing elective total colectomy in the period 1996–2010 in Denmark

	Ulcerative colitis	Crohn's disease	Ulcerative colitis and Crohn's disease*
Total number (n=1450)	938 (64.7%)	201 (13.9%)	311 (21.4%)
Males	485 (51.7%)	76 (37.8%)	137 (44.1%)
Females	453 (48.3%)	125 (62.2%)	174 (55.9%)
Age at operation			
0–39 years	436 (46.5%)	121 (60.2%)	161 (51.8%)
40–59 years	292 (31.1%)	55 (27.4%)	91 (29.3%)
≥60 years	210 (22.4%)	25 (12.4%)	59 (19.0%)
Number of annual colectomies for IBD performed in the surgical department			
≤3/year	131 (14.0%)	22 (11.0%)	45 (14.5%)
3–12/year	166 (17.7%)	28 (13.9%)	44 (14.1%)
>12/year	641 (68.3%)	151 (75.1%)	222 (71.4%)
Duration of hospitalisation before colectomy			
Admitted <8 days before colectomy	557 (59.4%)	136 (67.7%)	178 (57.2%)
Admitted ≥8 days before colectomy	381 (40.6%)	65 (32.3%)	133 (42.8%)
Medical treatment within 1 year before colectomy			
TNF- $\alpha$ and cyclosporine	64 (6.8%)	10 (5.0%)	37 (11.9%)
Reoperation within 30 days postoperatively	73 (7.8%)	21 (10.4%)	21 (6.8%)
Charlson Comorbidity Index Score			
0	705 (75.2%)	146 (72.6%)	224 (72.0%)
1–2	194 (20.7%)	45 (22.4%)	69 (22.2%)
≥3	39 (4.2%)	10 (5.0%)	18 (5.8%)
Colectomy type			
Colectomy with ileorectal anastomosis (KJFH00–01)	54 (5.8%)	42 (20.9%)	39 (12.5%)
Colectomy with ileostomy (KJFH10–11)	523 (55.8%)	99 (49.3%)	170 (54.7%)
Proctocolectomy with ileostomy (KJFH20–21)	147 (15.7%)	49 (24.4%)	65 (20.9%)
Restorative proctocolectomy ± ileostomy (KJFH30–33)	197 (21.0%)	5 (2.5%)	28 (9.0%)
Proctocolectomy with Koch reservoir (KJFH40)	1 (0.1%)	0 (0%)	0 (0%)
Other form of colectomy (KJFH96)	16 (1.7%)	6 (3.0%)	9 (2.9%)
Time period			
1996–2000	307 (32.7%)	67 (33.3%)	114 (36.7%)
2001–2005	343 (36.6%)	78 (38.8%)	95 (30.6%)
2006–2010	288 (30.7%)	56 (27.9%)	102 (32.8%)

\*Patients for whom codes for both ulcerative colitis and Crohn's disease were used at any preceding or subsequent admission or hospital contact.

IBD, inflammatory bowel disease; TNF, tumour necrosis factor.

of the patients included in the present study were coded for infection with *Clostridium difficile*.

Among all IBD patients, 1075 (74.1%) of elective cases and 1097 (76.2%) of emergency cases had a CCI score of 0 and 375 (25.9%) of elective cases and 342 (23.8%) of emergency cases had a score of 1 or higher. Comorbidity scores were distributed almost equally between the three IBD groups (tables 1 and 2). Total colectomy with ileostomy was performed more often in emergency cases than in elective cases (81.2% vs 54.6%). Proctocolectomy with ileostomy was carried out in 102 emergency cases (7.1%) and 261 elective cases (18%). Frequencies of procedures by type and disease groups are shown in tables 1 and 2.

### Mortality

Within 30 days following colectomy, 14 of the 1450 patients who underwent elective surgery died (1.0%), while 76 of the 1439 emergency patients (5.3%) died

(mortality difference = 4.3%; 95% CI 3.1% to 5.6%). Among ulcerative colitis patients, mortality was 0.9% (8/938) in the elective group and 5.2% in the emergency group. Patients with Crohn's disease undergoing emergency surgery had the highest 30-day mortality (11/136=8.1%).

Mortality was low in ulcerative colitis patients aged under 40 years (0.2%, table 3), both for elective and emergency surgery. For patients aged 60 years or older, mortality increased to 3.3% for those undergoing colectomy on an elective basis and to 18.4% for those undergoing this procedure on an emergency basis (mortality difference=15.1%; 95% CI 9.8% to 20.3%). Mortality was lowest in high-volume hospitals (0.5% for elective and 3.6% for emergency cases (mortality difference=3.1%; 95% CI 1.6% to 4.6%), table 3). Patients with high CCI scores also had high mortality. Table 3 shows mortality according to duration of hospitalisation prior to colectomy, colectomy type and time period.

**Table 2** Characteristics of patients with an IBD diagnosis undergoing emergency total colectomy in the period 1996–2010 in Denmark

	Ulcerative colitis	Crohn's disease	Ulcerative colitis and Crohn's disease*
Total number (n=1439)	1056 (73.4%)	136 (9.5%)	247 (17.2%)
Males	559 (52.9%)	62 (45.6%)	113 (45.7%)
Females	497 (47.1%)	74 (54.4%)	134 (54.3%)
Age at operation			
0–39 years	503 (47.6%)	56 (41.2%)	134 (54.3%)
40–59 years	286 (27.1%)	39 (28.7%)	65 (26.3%)
≥60 years	267 (25.3%)	41 (30.1%)	48 (19.4%)
Number of annual colectomies for IBD performed in the surgical department			
≤3/year	168 (15.9%)	31 (22.8%)	43 (17.4%)
3–12/year	186 (17.6%)	24 (17.6%)	50 (20.2%)
>12/year	702 (66.5%)	81 (59.6%)	154 (62.4%)
Duration of hospitalisation before colectomy			
Admitted <8 days before colectomy	296 (28.0%)	45 (33.1%)	85 (34.4%)
Admitted ≥8 days before colectomy	760 (72.0%)	91 (66.9%)	162 (65.6%)
Medical treatment within 1 year before colectomy			
TNF-α and cyclosporine	67 (6.3%)	12 (8.8%)	23 (9.3%)
Reoperation within 30 days postoperatively	102 (9.7%)	11 (8.2%)	27 (10.9%)
Charlson Comorbidity Index Score			
0	810 (76.7%)	96 (70.6%)	191 (77.3%)
1–2	194 (18.4%)	30 (22.1%)	49 (19.8%)
≥3	52 (4.9%)	10 (7.3%)	7 (2.8%)
Colectomy type			
Colectomy with ileorectal anastomosis (KJFH00–01)	38 (3.6%)	16 (11.8%)	19 (7.7%)
Colectomy with ileostomy (KJFH10–11)	875 (82.9%)	97 (71.3%)	196 (74.4%)
Proctocolectomy with ileostomy (KJFH20–21)	73 (6.9%)	8 (5.9%)	21 (8.5%)
Restorative proctocolectomy ± ileostomy (KJFH30–33)	31 (2.9%)	2 (1.5%)	4 (1.6%)
Proctocolectomy with Koch reservoir (KJFH40)	1 (0.1%)	0 (0%)	0 (0%)
Other form of colectomy (KJFH96)	38 (3.6%)	13 (9.6%)	7 (2.8%)
Time period			
1996–2000	371 (35.1%)	54 (39.7%)	90 (36.4%)
2001–2005	385 (36.5%)	36 (7.1%)	84 (34.0%)
2006–2010	300 (28.4%)	46 (11.0%)	73 (30.0%)

\*Patients for whom codes for both ulcerative colitis and Crohn's disease were used at any preceding or subsequent admission or hospital contact.  
IBD, inflammatory bowel disease; TNF, tumour necrosis factor.

**Table 3** Thirty-day mortality (in per cent) in patients with an IBD diagnosis undergoing total colectomy in the period 1996–2010 in Denmark, by emergency versus elective surgery

	Ulcerative colitis		Crohn's disease		Ulcerative colitis and Crohn's disease*	
	Emergency	Elective	Emergency	Elective	Emergency	Elective
All	5.2 (55/1056)	0.9 (8/938)	8.1 (11/136)	1.5 (3/201)	4.0 (10/247)	1.0 (3/311)
Males	5.8 (31/559)	0.8 (4/485)	6.5 (4/62)	2.6 (2/76)	2.7 (3/113)	0.7 (1/137)
Females	5.2 (24/497)	0.9 (4/453)	9.5 (7/74)	0.8 (1/125)	5.2 (7/134)	1.1 (2/174)
Age at operation						
0–39 years	0.2 (1/503)	0.2 (1/436)	0 (0/56)	0 (0/121)	0 (0/134)	0 (0/161)
40–59 years	1.7 (5/286)	0.0 (0/292)	5.1 (2/39)	0 (0/55)	3.1 (2/65)	1.1 (1/91)
≥60 years	18.4 (49/267)	3.3 (7/210)	22.0 (9/41)	12 (3/25)	16.7 (8/48)	3.4 (2/59)
Number of annual colectomies for IBD performed by the surgical department						
≤3/year	11.3 (19/168)	1.5 (2/131)	22.6 (7/31)	4.5 (1/22)	4.7 (2/43)	0 (0/45)
3–12/year	5.9 (11/186)	1.8 (3/166)	8.3 (2/24)	0 (0/28)	4.0 (2/50)	0 (0/44)
>12/year	3.6 (25/702)	0.5 (3/641)	2.5 (2/81)	1.3 (2/151)	3.9 (6/154)	1.4 (3/222)
Duration of hospitalisation before colectomy						
Admitted <8 days before colectomy	7.1 (21/296)	0.2 (1/557)	20.0 (9/45)	1.5 (2/136)	4.7 (4/85)	0.0 (0/178)
Admitted ≥8 days before colectomy	4.5 (34/760)	1.8 (7/381)	2.2 (2/91)	1.5 (1/65)	3.7 (6/162)	2.3 (3/133)
Medical treatment within 1 year before colectomy						
TNF-α or cyclosporine	0 (0/67)	0 (0/64)	0 (0/12)	0 (0/10)	0 (0/23)	0 (0/37)
Reoperation within 30 days postoperatively	8.8 (9/102)	4.1 (3/73)	18.1 (2/11)	4.8 (1/21)	7.4 (2/27)	0 (0/21)
Charlson Comorbidity Index Score						
0	2.2 (18/810)	0.6 (4/705)	3.1 (3/96)	0.0 (0/146)	2.1 (4/191)	0.9 (2/224)
1–2	12.9 (25/194)	1.6 (3/194)	20.0 (6/30)	4.4 (2/45)	6.1 (3/49)	1.4 (1/69)
≥3	23.1 (12/52)	2.6 (1/39)	20.0 (2/10)	10 (1/10)	42.9 (3/7)	0 (0/18)
Colectomy type						
Colectomy with ileorectal anastomosis (KJFH00–01)	15.8 (6/38)	0 (0/54)	6.3 (1/16)	0 (0/42)	0 (0/19)	0 (0/39)
Colectomy with ileostomy (KJFH10–11)	4.9 (43/875)	1.5 (8/523)	9.3 (9/97)	3.0 (3/99)	4.6 (9/196)	1.2 (2/170)
Proctocolectomy with ileostomy (KJFH20–21)	5.5 (4/73)	0 (0/147)	0 (0/8)	0 (0/49)	0 (0/21)	0 (0/65)
Restorative proctocolectomy ± ileostomy (KJFH30–33)	6.5 (2/31)	0 (0/197)	0 (0/2)	0 (0/5)	0 (0/4)	3.6 (1/28)
Proctocolectomy with Koch reservoir (KJFH40)	0 (0/1)	0 (0/1)	0 (0/0)	0 (0/5)	0 (0/0)	0 (0/0)
Other form of colectomy (KJFH96)	0 (0/38)	0 (0/16)	7.7 (1/13)	0 (0/6)	14.3 (1/7)	0 (0/9)
Time period						
1996–2000	5.9 (22/371)	0.3 (1/307)	7.4 (4/54)	1.5 (1/67)	1.1 (1/90)	0.9 (1/114)
2001–2005	5.2 (20/385)	0.3 (1/343)	2.8 (1/36)	2.6 (2/78)	6.0 (5/84)	1.1 (1/95)
2005–2010	4.3 (13/300)	2.1 (6/288)	13.0 (6/46)	0 (0/56)	5.5 (4/73)	1.0 (1/102)

\*Patients for whom codes for both ulcerative colitis and Crohn's disease were used at any preceding or subsequent admission or hospital contact. IBD, inflammatory bowel disease; TNF, tumour necrosis factor.

**Table 4** Mortality rate ratios in patients with ulcerative colitis undergoing total colectomy in the period 1996–2010 in Denmark

	Emergency		Elective	
	Crude	Adjusted	Crude	Adjusted
Females	Ref.	Ref.	Ref.	Ref.
Males	1.15 (0.68–1.97)	1.16 (0.68–1.98)	0.94 (0.23–3.74)	0.79 (0.20–3.19)
Age at operation				
0–39 years	Ref.	Ref.	Ref.	Ref.
≥40 years	26.18 (11.2–61.1)	17.78 (7.3–43.1)	24.65 (3.0–200)	24.51 (2.81–213.8)
Number of annual colectomies for IBD performed by the surgical department				
≤3/year	Ref.	Ref.	Ref.	Ref.
3–12/year	0.51 (0.24–1.06)	0.58 (0.28–1.23)	1.18 (0.20–7.08)	1.51 (0.25–9.18)
>12/year	0.30 (0.17–0.55)	0.46 (0.25–0.84)	0.30 (0.05–1.82)	0.63 (0.10–3.89)
Duration of hospitalisation before colectomy				
Admitted <8 days before colectomy	Ref.	Ref.	Ref.	Ref.
Admitted ≥8 days before colectomy	0.62 (0.36–1.06)	0.67 (0.39–1.16)	10.30 (1.27–83.6)	10.26 (1.25–84.2)
Charlson comorbidity index score				
0	Ref.	Ref.	Ref.	Ref.
≥1	7.20 (4.10–12.65)	2.56 (1.42–4.61)	3.05 (0.76–12.2)	1.06 (0.25–4.46)
Time period				
1996–2000	Ref.	Ref.	Ref.	Ref.
2001–2005	0.87 (0.48–1.60)	0.90 (0.49–1.64)	0.90 (0.06–14.31)	0.90 (0.06–14.54)
2005–2010	0.72 (0.36–1.43)	0.60 (0.30–1.20)	6.47 (0.78–53.7)	5.18 (0.62–43.6)

Adj, adjusted for age, gender and comorbidity.  
IBD, inflammatory bowel disease.

Numbers of outcomes in patients with Crohn's disease or mixed Crohn's disease/ulcerative colitis were too small to permit more detailed analysis of mortality.

In a subsequent analysis, we found that reoperation within 30 days occurred in 115 (7.9%) elective cases and in 140 (9.7%) emergency cases and was associated with particularly high mortality.

#### Prognostic factors in patients with ulcerative colitis

Crude and adjusted MRRs for patients with ulcerative colitis are shown in table 4. Higher age at operation (≥40 years) was associated with major increases in MRRs in both emergency and elective cases. A CCI score ≥1 was associated with an increased MRR after emergency colectomy but had no influence on MRR in patients undergoing elective colectomy. MRRs were lower for cases undergoing surgery at high-volume hospitals compared with low-volume hospitals. In the regression model for emergency colectomies, gender, duration of hospitalisation before colectomy and time period were not clearly associated with mortality. In the regression model for elective colectomies, hospitalisation for 8 days or more prior to surgery was associated with an increased MRR. Numbers were too low to permit calculation of MRRs for patients with Crohn's disease or with both ulcerative colitis and Crohn's disease.

#### DISCUSSION

Our study showed that 30-day postoperative mortality after total colectomy was 5.3% for IBD patients undergoing surgery on an emergency basis and 1% for those with elective procedures. We also found that comorbidity, surgery in a hospital performing few annual

colectomies and age over 40 were associated with increased mortality after emergency total colectomy in patients with ulcerative colitis. Age over 40 and hospitalisation for 8 days or more prior to colectomy were associated with increased mortality in ulcerative colitis patients undergoing elective total colectomy.

Our data extend previous research with recent population-based data. Mortality after emergency total colectomy for ulcerative colitis was as high as 27%<sup>19 30–32</sup> in the past. More recent data from tertiary referral centres indicate inhospital mortality of <0.6%.<sup>20 33 34</sup> However, a short report on a small number of patients treated at a district general hospital in the UK raised concerns that mortality remains considerably higher than estimates based on tertiary centres.<sup>24</sup> This was confirmed in a record linkage study conducted in England for the period 1998–2000 by Roberts *et al.* In that study, 30-day mortality was 0.8% following elective colectomy and 5.7% following emergency colectomy in ulcerative colitis patients.<sup>21</sup> A later study by Kaplan *et al.*<sup>22</sup>, based on the American Nationwide Inpatient Sample database, reported similar figures of 0.7% and 5.4% for inhospital mortality following elective and emergency colectomy, respectively, in ulcerative colitis patients. This large-scale American study, covering approximately 20% of Veterans' Administration admissions, identified low hospital volume for colectomies, age over 40, comorbidity and hospitalisation for more than 7 days prior to colectomy as independent prognostic factors. Our study supports these previous population-based investigations, showing that 30-day postoperative mortality after total colectomy is probably not as low as suggested by reports from tertiary referral centres. In addition, both the

American study and our study underscore that a high volume of these surgeries—and consequently a high degree of experience—may be important in reducing postoperative mortality after both emergency and elective total colectomy in IBD patients.<sup>35</sup>

Our finding of 8.1% 30-day mortality after emergency surgery in Crohn's disease patients contrasts with the Roberts *et al*<sup>21</sup> study, which found a 30-day mortality of only 2.9%. The main reason for this difference may be that we included only patients with total colectomy, while Roberts *et al* included patients undergoing all types of colectomy, including right hemicolectomy. Regrettably, the number of patients in the Crohn group was low precluding detailed statistical analysis of this cohort of patients. The group of patients with both a diagnosis of ulcerative colitis and Crohn's disease was relatively large, and we assume that it includes patients, whose diagnosis has indeed been reclassified. It may also include patients, who at a single occasion has received an incorrect diagnosis because we expanded our search for diagnosis to a period beginning in 1997 and continuing until conclusion of the study. In this respect, our study was different to the previous population-based studies.<sup>21–23</sup>

The high mortality observed in our study calls for a critical revision of indications for elective and emergency colectomy in patients with Crohn's colitis. A key recommendation is to treat patients with severe ulcerative colitis in highly specialised centres. Similar recommendations could be made for patients with Crohn's disease, although the number of patients included in the present study was too low to provide statistical support.

Our study also confirmed that older age, emergency procedures and a high degree of comorbidity are associated with increased mortality after intestinal surgery.<sup>22 23 36 37</sup> In addition, it is known from population-based studies that hospitalisation for ulcerative colitis has a two-peak age incidence in a number of countries including Denmark.<sup>38</sup> We found that a high proportion of patients with ulcerative colitis underwent total colectomy after age 60. An elective procedure performed earlier in life would most likely reduce mortality in these patients. Interestingly, comorbidity had no influence on MRRs among patients undergoing elective surgery. This suggests that interventions to address comorbidities such as elevated blood pressure, arrhythmias and diabetes may have taken place preoperatively, ensuring a safer postoperative course. It is not possible from the present result to speculate about the influence of surgical procedure on mortality. First of all, the number of patients in the different subgroups is fairly low precluding statistical subgroup analysis, and second, the preoperative condition of the patients has probably had influence on the choice of surgical procedure.

When medical treatment cannot achieve remission, delaying surgery can increase morbidity and mortality.<sup>19 39</sup> Thus, Kaplan *et al*<sup>22</sup> reported more than a doubling of

the MRR among patients who were hospitalised (and presumably treated medically) for more than 7 days prior to surgery. Our study confirmed these findings for the subgroup undergoing elective surgery.

The main strength of the present study is its nationwide population-based design in the setting of a free tax-supported healthcare system with complete information on follow-up. Moreover, we used a validated approach to identify IBD patients undergoing surgery.<sup>40</sup> These features ensure generalisability of our results and minimise selection bias. In addition, we were able to adjust for a number of important covariates, including comorbidity, for which we had high-quality data.<sup>41</sup>

Our study also had several limitations. Although we used a validated approach to identify colectomized IBD patients, approximately 16% had codes corresponding to both Crohn's disease and ulcerative colitis. As mentioned, this is most likely due to some degree of coding error. We therefore grouped IBD patients with mixed codes separately to minimise misclassification of the Crohn's and ulcerative colitis groups. We also did not have access to important clinical parameters, such as reasons for deciding to proceed with surgery or to discontinue medical treatment. Thus, we were unable to investigate the role of these important issues in relation to postoperative mortality. Finally, registration of rescue therapy with cyclosporine or infliximab was probably incomplete because such registration has only recently become compulsory in our country.

In conclusion, we observed high 30-day mortality among IBD patients undergoing emergency total colectomy. Among patients with ulcerative colitis, 30-day mortality was 5.2% after total emergency colectomy, and among patients with Crohn's disease, it was 8.1%. Low hospital volume of colectomy, comorbidity and age over 40 were important prognostic factors.

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